EFFECTS OF EXEMPLAR TRAINING IN EXCLUSION RESPONDING ON AUDITORY-VISUAL DISCRIMINATION TASKS WITH CHILDREN WITH AUTISM

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In Experiment 1 with 7 autistic children (3 to 6 years old), auditory-visual exclusion was tested with four unknown word–item pairs for each child. One child demonstrated exclusion and positive learning outcomes unequivocally with the four auditory-visual relations. Three children demonstrated exclusion, though inconsistently, and failed to demonstrate positive learning outcomes. The remaining 3 children failed to demonstrate exclusion; therefore, the learning outcome test was omitted. The 6 children who failed to demonstrate exclusion or positive learning outcomes participated in the second experiment. In Experiment 2, nonreinforced exclusion trials with four new unknown word–item pairs were included in trial blocks that also contained reinforced exclusion trials with the unknown exemplars from Experiment 1. Five children demonstrated exclusion with the new word–item pairs, and 4 of these demonstrated positive learning outcomes in further tests. One child demonstrated some limited but inconsistent improvement in exclusion and was not tested for learning outcomes. The data suggest that contemporaneous presentation of multiple examples of reinforced exclusion facilitated nonreinforced exclusion performances and that the resulting reduction in errors was critical in producing accurate learning outcomes with the new word–item discriminations.

DESCRIPTORS: autism, exclusion-based learning, multiple-exemplar training, generalization

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A recent cross-disciplinary initiative between researchers in behavior analysis and child language development has highlighted a link between the exclusion phenomenon studied in behavior analysis and fundamental vocabulary acquisition processes identified in psycholinguistic research (e.g., Wilkinson, Dube, & McIlvane, 1996, 1998; Wilkinson & McIlvane, 1997). Through such discourse, there is increasing recognition that the exclusion paradigm has considerable potential as a method for teaching basic vocabulary to persons with intellectual and linguistic disabilities (e.g., Carr & Felce, 2000; Wilkinson & Tager-Flusberg, 1998).

Psycholinguistic studies in fast mapping (e.g., Carey, 1978; Dollaghan, 1987; Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; Mervis & Bertrand, 1995, 1997; Rice, Buhr, & Nemeth, 1990; Romski, Sevcik, Robinson, Mervis, & Bertrand, 1996) and behavior-analytic studies in exclusion-based learning (e.g., Dixon, 1977; Lipkens, Hayes, & Hayes, 1993; McIlvane, Kledaras, Lowry, & Stoddard, 1992; McIlvane, Munson, & Stoddard, 1988; McIlvane & Stoddard, 1981; McIlvane, Withstandley, & Stoddard, 1984; Wilkinson & Green, 1998) are parallel research areas. Both areas investigate how children can acquire new relations between spoken words and referents in the absence of explicit teaching and with minimal exposure to the new relations. Although the experimental contexts vary between naturalistic tasks in psycholinguistic research and discrete-trial conditional discrimination procedures in behavior-analytic studies, the basic research paradigms have been noted to

yield comparable outcomes across the different experimental contexts (e.g., see Wilkinson et al., 1996).

Although a variety of stimuli have been used in exclusion studies, the relevance of exclusion-based auditory-visual conditional discriminations to investigating basic vocabulary acquisition processes can be described succinctly by designating auditory stimuli as "words" and visual stimuli as "pictures." The simplest form of exclusion trial follows a matching-to-sample or conditional discrimination format, in which a novel word is spoken as the sample and an unknown picture (i.e., one that has no established relation with a corresponding word for the participant) is presented along with one or more previously known pictures as comparisons. Demonstration of an exclusion-based conditional discrimination requires that the unknown picture is selected when the novel word is spoken. The corresponding term for this process is *disambiguation* in psycholinguistic research (e.g., Merriman & Bowman, 1989; Merriman, Marazita, & Jarvis, 1993), and this is considered a necessary prerequisite skill for fast mapping new words. A further test using learning outcome trials then can assess whether the newly known word–picture relations remain stable in the absence of a basis for exclusion or disambiguation. Two comparison pictures are presented, each of which has been newly defined through exclusion trials. The consistent selection of each picture in response to its newly known word indicates that each new relation has been established. In fast-mapping terms, it then can be concluded that a one-to-one map has been established between each picture and its corresponding word (e.g., Wilkinson & Green, 1998).

Some of the participants in the aforementioned behavior-analytic and psycholinguistic studies demonstrated learning of new word–referent relations in both receptive and expressive modes (e.g., McIlvane et al., 1992; Romski et al., 1996). However, positive outcomes were by no means universal, and mapping skills were shown frequently to be absent, limited, or unstable for many participants. The nature of the limitations varied: Some participants failed at the outset to define the new relations through exclusion or disambiguation processes (e.g., see Mervis & Bertrand, 1995; Rice et al., 1990; Romski et al.). Others, after initially having defined the new relations through exclusion, failed to demonstrate stable word–picture relations in learning outcome trials presented in a nonexclusion format (e.g., see Dixon, 1977; Rice et al.; Wilkinson & Green, 1998).

Nevertheless, despite these limitations, previous studies have illustrated the potential of exclusion procedures in facilitating the formation of linguistic relations in persons with intellectual and language disabilities. Participants in these studies have demonstrated the emergence of relations between objects and spoken words (e.g., McIlvane & Stoddard, 1981, 1985), between pictures and spoken words (e.g., Wilkinson & Green, 1998; Wilkinson & McIlvane, 1994a, 1994b), and between printed words and spoken words (e.g., de Rose, de Souza, & Hanna, 1996; de Rose, de Souza, Rossito, & de Rose, 1992; Wilkinson & Albert, 2001).

The ability to acquire such relations is essential for persons with intellectual and language disabilities to use augmentative communication systems, which employ various linguistic media, including pictures, printed and spoken words, and graphic symbols. Moreover, psycholinguistic evidence indicates that level of achievement in acquiring symbolic language forms is related to the presence of mapping skills in persons with intellectual and linguistic disabilities (e.g., Romski et al., 1996). Therefore the development of procedures to aid children in establishing the prerequisite disambiguation or exclusion skills for mapping could contrib-

ute substantially to the efficiency with which they acquire new vocabulary-based linguistic relations.

Wilkinson and Green (1998) suggested that the stability of new words seems especially vulnerable to disruption in children with a language disability, particularly when the demands are to learn multiple new words. Wilkinson and Green assessed the disambiguation and learning outcome performances of 10 youths with moderate to severe mental retardation and language disability. The study compared performances in auditory-visual lexical tasks using a modified exclusion procedure, designed to limit new-map disruption (Wilkinson & McIlvane, 1994a, 1994b) and a traditional exclusion procedure. Briefly, in the modified procedure, termed the successive exposure condition, the first new word–picture relation was defined for the participants in exclusion trials in the first session. This newly defined relation was then used as a basis for exclusion for the second new word–picture relation in the next session. In the traditional concurrent exposure condition, both new word–picture relations were introduced during the same session, using the same pre-known word–picture relations as a basis for exclusion. Although individual performances varied among participants, overall learning outcomes of the group were enhanced substantially in the successive exposure condition. This suggests that mapping skills can be enhanced through particular exclusion-trial configurations, which minimize the potential for the disruption of multiple newly formed word–referent relations.

The participants in Wilkinson and Green's (1998) study demonstrated exclusion responding as a prerequisite skill through their performances in the initial disambiguation trials, and therefore the successive exposure procedure was able to build on this skill in teaching multiple new words. However, as noted previously, many individuals with severe language disabilities do not demonstrate exclusion even at a fundamental level. These individuals should benefit substantially from procedures that help to establish exclusion responding as a prerequisite skill that can be expanded with effective methods for teaching multiple new words.

The logic of relational frame theory (RFT) suggests a strategy whereby initial exclusion responding might be achieved. RFT applies a behavior-analytic interpretation to the acquisition of symbolic relations between a series of stimuli (e.g., between spoken and written words, pictures, and graphic symbols) in language development. According to RFT, relational framing (i.e., arbitrarily applicable relational responding) is known as a generalized operant response class that is established, at least in part, by an appropriate history of reinforcement across exemplars (see Barnes, 1994, 1996; Barnes & Holmes, 1991; Barnes & Roche, 1996; Hayes, 1991, 1994; Hayes & Hayes, 1992). For example, during early language interactions, children are often asked to repeat the names of objects they are shown. On other occasions, they are also taught to identify these same objects (e.g., by pointing) when they hear the appropriate name. Initially, these object-to-name and name-to-object relations are taught separately, but RFT proposes that with sufficient exposure to these relations over a range of exemplars, symmetrical object-to-name/name-to-object responding becomes established as an overarching behavioral principle that extends to novel instances of object and spoken-name relations. Thus, on future occasions, when the child is exposed to a novel object name in the presence of that object, he or she may later identify this object from among others on hearing that name, without specifically having been taught to do so.

In applying this logic to the principle of exclusion-based responding in linguistic relations, Wilkinson et al. (1996) noted that

Table 1
Language Entry Skill Levels

Child	Age (years–months)	Expressive	Receptive
P1	6–10	No speech and few signs	Single-word level (nouns and verbs)
P2	6–2	Immediate echolalia	Single-word level (nouns and verbs)
P3	3–11	Immediate and delayed echolalia	Single-word level (nouns and verbs)
P4	3–9	Immediate and delayed echolalia	Single-word level (nouns and verbs)
P5	5–3	No speech and no signs	Single-word level (nouns)
P6	5–3	No speech and no signs	Preverbal level
P7	5–2	One repetitive phrase	Preverbal level

it would predict that novel instances of exclusion should occur after examples of exclusion are reinforced directly. Furthermore, reinforcement-based teaching procedures may be particularly effective if trial configurations are designed to maximize the potential for generalization across exemplars (e.g., through multiple-exemplar teaching procedures; Stokes & Baer, 1978). Therefore, this prediction was applied in the current experiments as a rationale for designing the configuration of trial blocks used to teach exclusion.

Experiment 1 examined exclusion abilities and learning outcomes in an auditory-visual conditional discrimination task for 7 children with autism who had severe receptive and expressive language disabilities. Experiment 2 examined the effect of reinforced exclusion trials with multiple exemplars on performances of emergent exclusion and learning outcomes with new stimuli. The participants were 6 children for whom either one or both of these skills were missing in Experiment 1.

EXPERIMENT 1

METHOD

Participants

Seven children (P1 through P7) who had been diagnosed with autism from special units for autism in southeast Wales participated after formal consent from their parents

was obtained. The units' speech and language therapists assessed the children's linguistic levels using the Derbyshire Language Scheme (Knowles & Masidlover, 1982) before the study commenced. Table 1 describes the assessment outcomes for each child.

Setting and Materials

The researcher and participant were seated opposite each other at a small table in an unoccupied classroom, which was empty except for the experimental materials. At first, commercially produced color photographs (4 in. by 5 in.) of children's everyday items were introduced as visual stimuli for all children. However, objects were subsequently used with P4, P5, P6, and P7 because they did not attend to the photographs in the context of the task but instead were inclined only to chew, bend, or throw them. The photographs were used for P1, P2, and P3.

Procedure

The sequence and protocols for the baseline, exclusion, and learning outcome phases are presented in Figure 1.

Phase 1: Baseline trials. The aim of the baseline test was to identify two known items (selected on a minimum of 9 of 10 trials) and eight unknown items (selected on a maximum of 5 of 10 trials) for each child. Ten items, forming five visual comparison pairs, were presented in a series of auditory-visual conditional discriminations. There

PHASE 1
Identifying Known & Unknown Items

Item pairs presented in mixed blocks x 10 trials
10 requests per item

Known (Items 1 & 2)   *Unknown* (Items 3-10)
Correct selection = 9/10 min. Correct selection = 5/10 max.

PHASE 2
Exclusion Test

Known-Known   *Known-Unknown*
(Items 1 & 2)   (Items 1 & 2 paired with 3-6)
Known noun requested   Unknown noun requested

Participants scoring significantly above chance in Exclusion Test proceed to Phase 3

PHASE 3
Learning Outcome Test

Unknown-Unknown
(Items 3-6 presented in pairs)
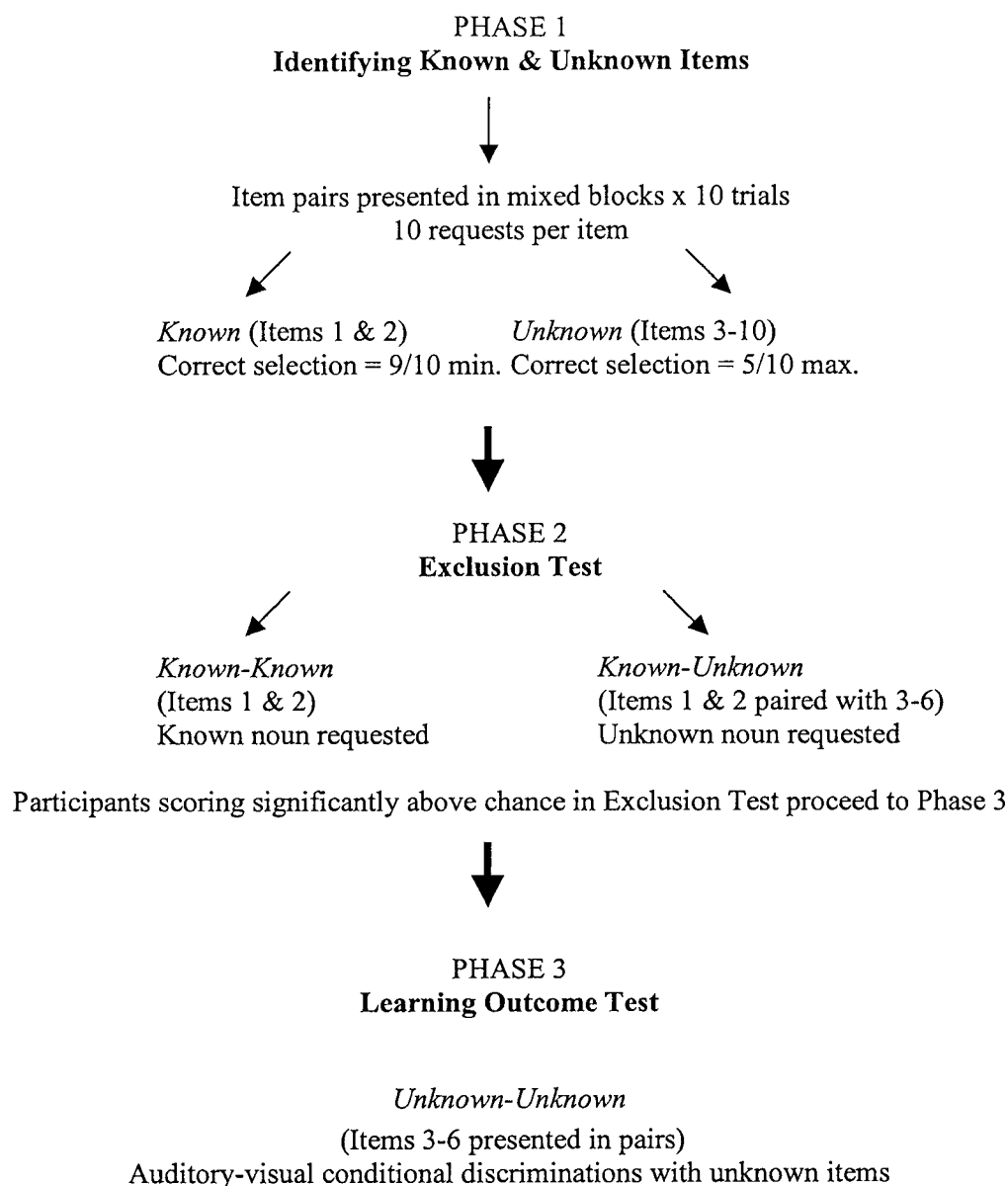Auditory-visual conditional discriminations with unknown items

Figure 1.   Schematic illustration of the sequence of test phases and trial block protocols in Experiment 1.

were 10 trials per block, allowing one request per item. Each block was repeated 10 times, providing 10 requests per item. Some scores were outside the parameters for identifying known and unknown items (i.e., scores that were within the 6 of 10 to 8 of 10 range). Therefore, 10 new items were presented to each child in a further 10 blocks of 10 trials each. Although the final

numbers of known and unknown items varied among the children, at least two known and eight unknown items were identified for each child on completion of baseline trials with the second set of items (a total of 200 baseline trials).

Auditory-visual conditional discriminations involved presentation of pairs of items (i.e., objects or photographs) and a request

Table 2
Known (1 and 2) and Unknown (3 through 10) Items Identified for Each Child

Child	1	2	3	4	5	6	7	8	9	10
P1	Cup	Shoe	Torch	Lamp	Ruler	Glue	Phone	Boat	Train	Glove
P2	Sock	Brush	Scissors	Ruler	Bowl	Watch	Plane	Bag	Phone	Glass
P3	Clock	Cup	Crayon	Pen	Comb	Knife	Paint	Ruler	Fork	Belt
P4	Torch	Drum	Fork	Watch	Knife	Ruler	Towel	Glass	Phone	Comb
P5	Hat	Shoe	Bowl	Spoon	Key	Fork	Knife	Sock	Comb	Bricks
P6	Hat	Brush	Bowl	Ruler	Spoon	Knife	Comb	Key	Fork	Cup
P7	Shoe	Car	Hat	Spoon	Ruler	Paint	Knife	Pen	Cup	Key

Note. Minimum 9 of 10 correct conditional discriminations identified known items. Maximum 5 of 10 correct conditional discriminations identified unknown items.

for one of the items by name. Methods of item presentation, requests, and responses differed slightly among children according to different teaching practices at their schools. For children with established "giving" behavior (P1, P2, P5, P6, and P7), the items were placed on the table and "Give me [name]" was the spoken request. A response was scored as correct if the child gave the item corresponding with the spoken name. For children without giving behavior (P3 and P4), the researcher held the items in front of the child and said, "Where's the [name]?" The objects were then placed on the table, and the request was repeated. A response was scored as correct if the child touched or picked up the item corresponding with the spoken name. If a child failed to respond on any given trial, scoring of the trial was postponed until the end of the session when the trial was presented again: Failure to respond on a repeated trial was scored as an incorrect response. Left and right presentation of comparison pairs varied equally within each block of trials. Correct responses on trials were never reinforced; however, reinforcement (praise and a preferred candy or snack) was delivered for compliance with instructions related to the experimental context (e.g., "sit up," "look at me," "hands down"). Reinforcement for compliance was delivered on a variable-ratio (VR) 3.3 schedule (three of the trials in each block of 10

trials). The duration of each session was a maximum of 15 min. All the children completed at least one block per session, and an additional block was presented depending on the child's cooperation and the time available in the session. Baseline sessions were conducted three to four times weekly during the school's first half-semester (6 weeks). In most cases, the two known items had not formed a comparison pair in baseline trials, so they were paired in an additional two blocks of 10 conditional discriminations to verify that selection was based on auditory control and not on item preference. The final pool of items for each child is specified in Table 2.

Phase 2: Exclusion test. The first four unknown items listed (i.e., Items 3 to 6) were used in Experiment 1; the next four items (Items 7 to 10) were reserved for Experiment 2. Five blocks of 12 auditory-visual conditional discrimination trials were presented to each child over five sessions. No more than one session per day was conducted and the sessions were completed within 10 days. Each block contained four baseline trials in which both known items were presented together (20 baseline trials over the five sessions with 10 requests per item) and eight exclusion probe trials in which each of the four unknown items was paired and requested once with each of the two items from the baseline conditional discrimination (40 ex-

clusion probe trials over five sessions with 10 requests per item). Left and right presentation of comparison pairs varied equally across the session.

Phase 3: Learning outcome test. A learning outcome test was given to each child whose correct selections over the 40 exclusion probes were significantly greater than chance using a binomial test (i.e., 26 of 40). Four blocks of trials were presented in which Items 3 to 6 were paired as comparisons on a rotating basis to minimize the possibility that the children could exclude consistently on the basis of their higher scoring nouns in the exclusion test. Each item was requested a total of 10 times over the four trial blocks, using the same reinforcement schedule for general compliance as in previous phases.

Reliability and Recording Procedures

Responses were recorded trial by trial on prepared scoring sheets that specified the order of trial presentation, the target noun for selection, and the reinforcement schedule. The sessions were recorded on video; a trained observer independently scored recordings for a random sample of 33% of all sessions per child over the two experiments using identical scoring sheets and compared these scores with the original records. The reliability score was calculated by dividing the number of agreements by the sum of agreements and disagreements and multiplying by 100%. The reliability ratings for each child were for P1, 100%; P2, 99.5%; P3, 100%; P4, 100%; P5, 99.5%; P6, 96%; P7, 99%.

RESULTS

Exclusion Test Scores

The left column of each chart in Figure 2 shows that most of the children maintained their baseline conditional discrimination score levels for known items during the exclusion tests. Two exceptions to this were P4, whose score for Item 1 decreased from 9 of

10 in baseline to 5 of 10 in exclusion tests, and P6, whose scores decreased only slightly from 9 of 10 to 8 of 10 for Item 1 and from 10 of 10 to 8 of 10 for Item 2. A binomial test was used with each child's total score over the 40 exclusion probes for unknown items (gray bars in right section of each chart) to determine which scores over 50% were significantly different from chance. Correct scores were significant for 4 children (P1, 27 of 40, $p < .025$; P3, 26 of 40, $p < .05$; P4, 33 of 40, $p < .005$; P5, 37 of 40, $p < .005$) and were nonsignificant for the remaining 3 children (P2, 20 of 40; P6, 15 of 40; P7, 16 of 40); the learning outcome test was omitted for these 3 children.

Learning Outcome Test Scores

The learning outcome test was given to P1, P3, P4, and P5, whose exclusion probe scores were at above-chance levels. The score for P5 remained above chance in the learning outcome test: Exclusion probe scores were 37 of 40 and learning outcome scores were 36 of 40. Correct scores in learning outcome tests failed to reach significance for the other 3 children: P1, from 27 of 40 (exclusion probe) to 24 of 40 (learning outcome); P3, from 26 of 40 (exclusion probe) to 24 of 40 (learning outcome); P4, from 33 of 40 (exclusion probe) to 24 of 40 (learning outcome). This test was omitted for P2, P6, and P7.

DISCUSSION

Correct exclusion responses in the Phase 2 test were significantly greater than chance for 4 children (P1, P3, P4, and P5). However, only P5 maintained this level of accuracy when the unknown items were paired as comparisons in the Phase 3 learning outcome test. P2, P6 and P7 failed to demonstrate exclusion reliably and therefore they did not receive the learning outcome test.

The time series data for P5 (see Figure 3) illustrate his increasing accuracy in exclusion
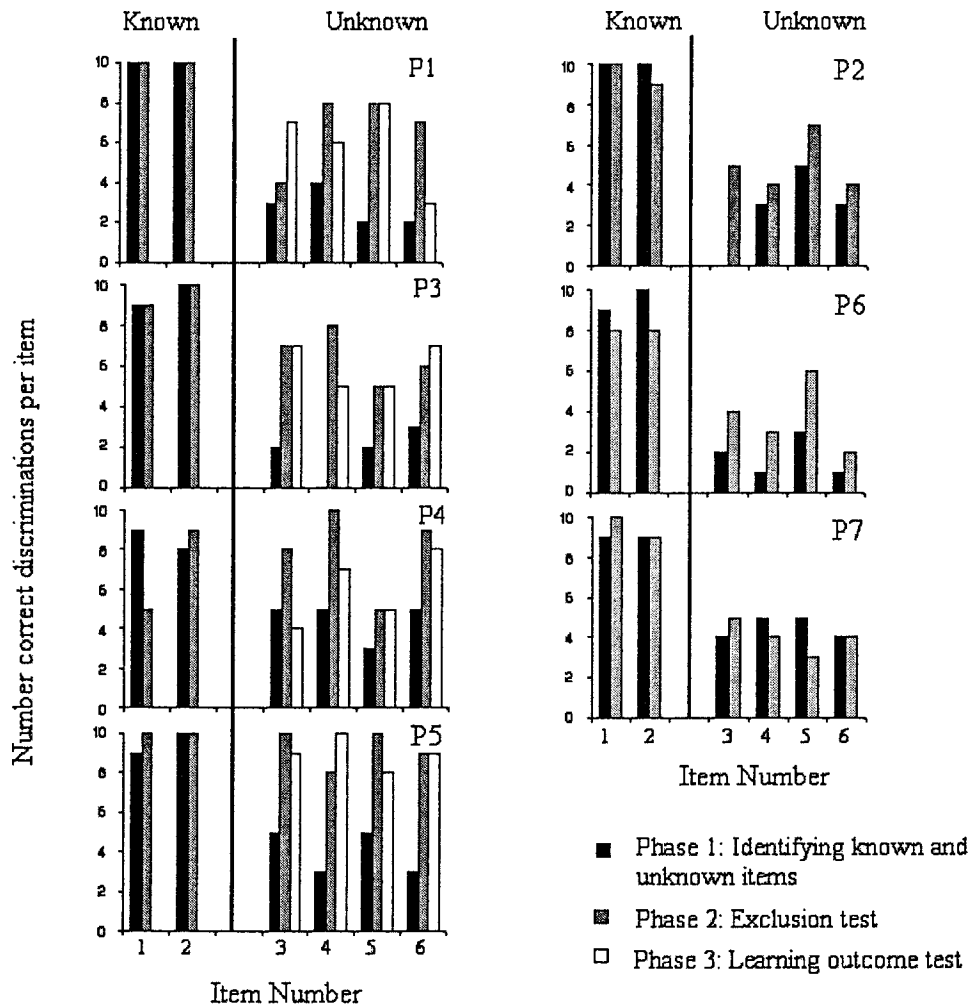
Figure 2. In each chart, the vertical axis specifies the number of correct auditory-visual conditional discriminations achieved in each condition. The horizontal axis specifies the item number. The left section illustrates scores for known Items 1 and 2 during baseline tests (black bars) and during exclusion tests (gray bars). The right section illustrates scores for unknown Items 3 through 6 during baseline tests (black bars), exclusion tests (gray bars), and learning outcome tests (white bars).

trials to 100% by the third session in Experiment 1, which was maintained over the remaining two sessions. This improvement suggests that for P5, repeated exposure to nonreinforced exclusion trials rapidly secured consistent accuracy in his exclusion performance. Therefore it seems reasonable to conclude that exclusion-based responding was already within his preexperimental rep-

ertoire. Repeated exposure to exclusion trials may also account for the performance by P1, whose exclusion score improved from 3 of 10 in Session 1 to 7 of 10 by Session 5, with a general, though somewhat variable, increase in accuracy over the whole series. Nevertheless, even if P1's improving exclusion performance was indeed due to exposure to nonreinforced exclusion trials, there
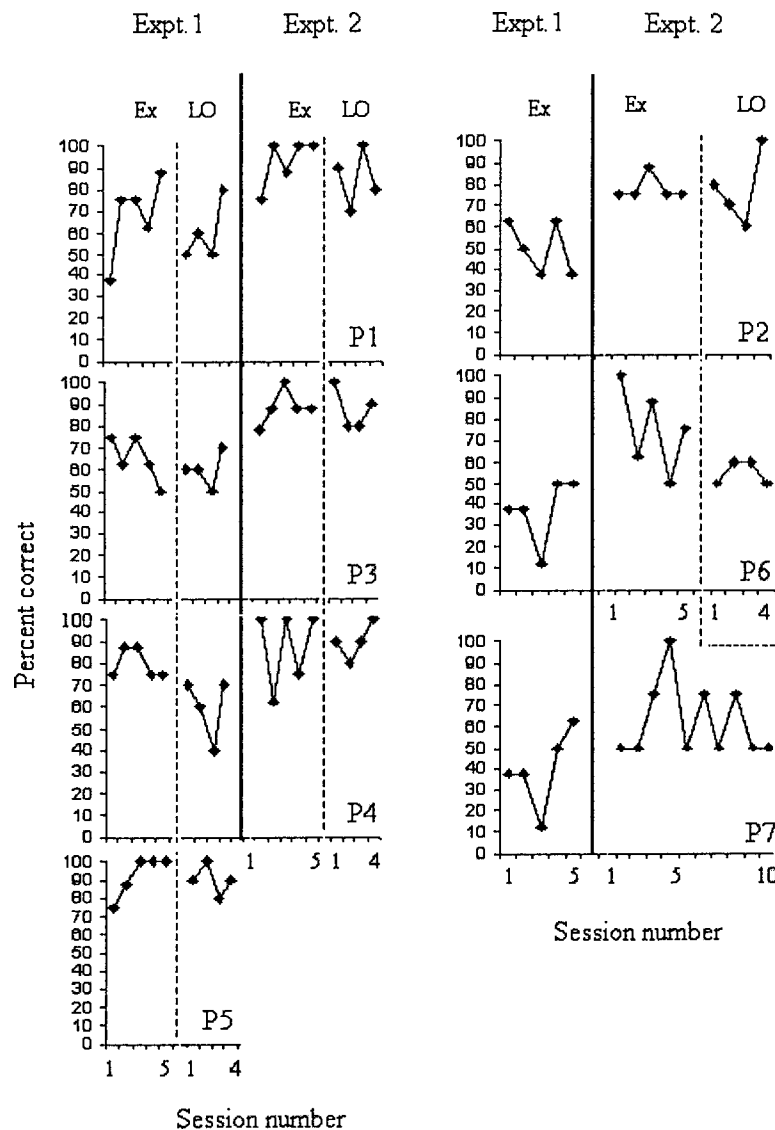
Figure 3. Each data point specifies the number of correct nonreinforced exclusion trials (Ex) and learning outcome trials (LO) per test block, for each participant in Experiments 1 and 2.

was no corresponding improvement in his accuracy in the learning outcome trials. The overall error frequency for P1 was similar to the frequencies for P3 and P4, who also demonstrated exclusion at above-chance levels but inconsistent learning outcomes. Therefore, it seems possible that a reduction in exclusion errors may promote a corresponding reduction in learning outcome errors for P1, P3, and P4. However, the grad-

ual improvement in exclusion-based responding by P1 in this experiment limits subsequent evaluation of the effects of a remedial strategy directly on his exclusion responding.

Although there were differences in overall error frequencies for the remaining participants (P2, P3, P4, P6, and P7), Figure 3 illustrates that none of them demonstrated an increasing trend in accuracy over the se-

ries of exclusion test sessions. Therefore, there seemed to be no gradual stabilizing of exclusion responding as a function of exposure to nonreinforced exclusion trials for these participants.

Individual performances suggest that exclusion-based responding was evident but tentative with P1, P3, and P4, although they demonstrated considerably less consistency than P5 across all four items (see Figure 2). In contrast, exclusion-based responding was absent for P2, P6, and P7.

In summary, the data suggest that although some participants seemed to show a tendency towards exclusion-based responding, exclusion was not established securely as a principle for responding in auditory-visual conditional discriminations and was absent entirely for others. Experiment 2 explored whether establishing exclusion more securely as a contextual basis for responding could reduce error rates and could provide a stronger opportunity for auditory-visual relations to develop. Consistent with RFT and with pragmatic recommendations for generalization procedures (Stokes & Baer, 1978), a reinforcement-based multiple-exemplar procedure was used to strengthen exclusion-based responding with all participants except P5.

EXPERIMENT 2

In Phase 1 an emergent exclusion test examined whether the participants demonstrated emergent exclusion in auditory-visual conditional discrimination relations with a previously untested set of words and items (Items 7 to 10). The nonreinforced (emergent) exclusion trials were set in a baseline of reinforced or corrected exclusion trials with previously tested items (Items 3 to 6). In Phase 2 a learning outcome test was given to participants with significant scores in the Phase 1 emergent exclusion test. This examined whether emergent auditory-visual exclusion relations with Items 7 to 10 yield-

ed learning outcomes that were comparable to exclusion test performances.

Method

Participants, Setting, and Stimulus Materials

Six children from Experiment 1 (P1, P2, P3, P4, P6, and P7) participated. The experimental setting and stimulus materials were the same as for Experiment 1.

Procedure

Figure 4 specifies the trial configurations and protocols for the exclusion and learning outcome phases.

Phase 1: Exclusion test. Twenty sets of four trials were constructed. Each set (or block) of four trials contained three trial types. With the first trial type, one known item (Item 1 or 2) was paired with one of the unknown items presented in Experiment 1 (Item 3, 4, 5, or 6), and the unknown item was requested. A correct response on this trial was reinforced with praise and a preferred candy or snack. For incorrect responses, the researcher returned the incorrect item, saying "No, not the [known name], give me the [unknown name]." Correct responses on repeated trials were reinforced. The second trial type was identical to the first except that the known item (Item 1 or 2) was requested and there were no differential consequences for correct or incorrect responses. The third trial type was identical to the second except that one known item (Item 1 or 2) was paired with one of the unknown items that was not presented in Experiment 1 (Item 7, 8, 9, or 10), and the unknown item was requested.

The presentation sequence for trial types varied in each four-trial set. Pairings of known with unknown comparison items were rotated, and left and right presentation of items varied unsystematically but equally over each session. With one exception (P7), all the children completed five sessions with-

PHASE 1
Exclusion Sets

20 sets x 4 trials:

Known-Unknown (1 trial): Item 1 or 2 paired with 3, 4, 5 or 6
Unknown item requested (reinforced)

Known-Unknown (1 trial): Item 1 or 2 paired with 3, 4, 5 or 6
Known item requested (not reinforced)

Known-Unknown (2 trials): Item 1 or 2 paired with 7, 8, 9 or 10
Unknown item requested (not reinforced)

⬇

PHASE 2
Learning Outcome Test

Unknown-Unknown
(Items 7-10 presented in pairs)
Auditory-visual conditional discriminations with unknown items

Figure 4.   Schematic illustration of the sequence of test phases and trial block protocols in Experiment 2.

in 10 days. Because P7's cooperation could be maintained for only short periods (5 to 10 min), he received two sets of four trials per session, permitting the same 1:4 reinforcement schedule as for the other children, and he completed 10 sessions within 17 days.

Phase 2: Learning outcome test. Four blocks of 10 conditional discrimination trials were constructed in which Items 7 to 10 were paired as comparisons. Pairings were rotated so that the pairs were different in each block. Left and right presentation of items varied equally. Each picture (or object) was requested a total of 10 times over the four blocks of trials. The reinforcement schedule used in Phase 2 was identical to the one used in Experiment 1. That is, correct responses on trials were never reinforced; however, reinforcement (praise and a preferred candy or snack) was delivered for compliance with instructions related to the experimental context (e.g., "sit up," "look at me," "hands down"). Reinforcement for compliance was delivered on a VR 3.3 schedule (three of the trials in each block of 10 trials). Participants received one block of trials per day, and all the sessions were completed within 8 days for each child.

RESULTS

Exclusion Test Scores

Figure 5 shows that 3 children (P1, P2, and P3) maintained their baseline conditional discrimination score levels (black bars) for known items (Items 1 and 2) during the exclusion tests (gray bars). Former levels decreased only slightly for P4, from 10 of 10 to 8 of 10 with Item 1; for P6, from 10 of 10 to 7 of 10 with Item 2; and for P7, from
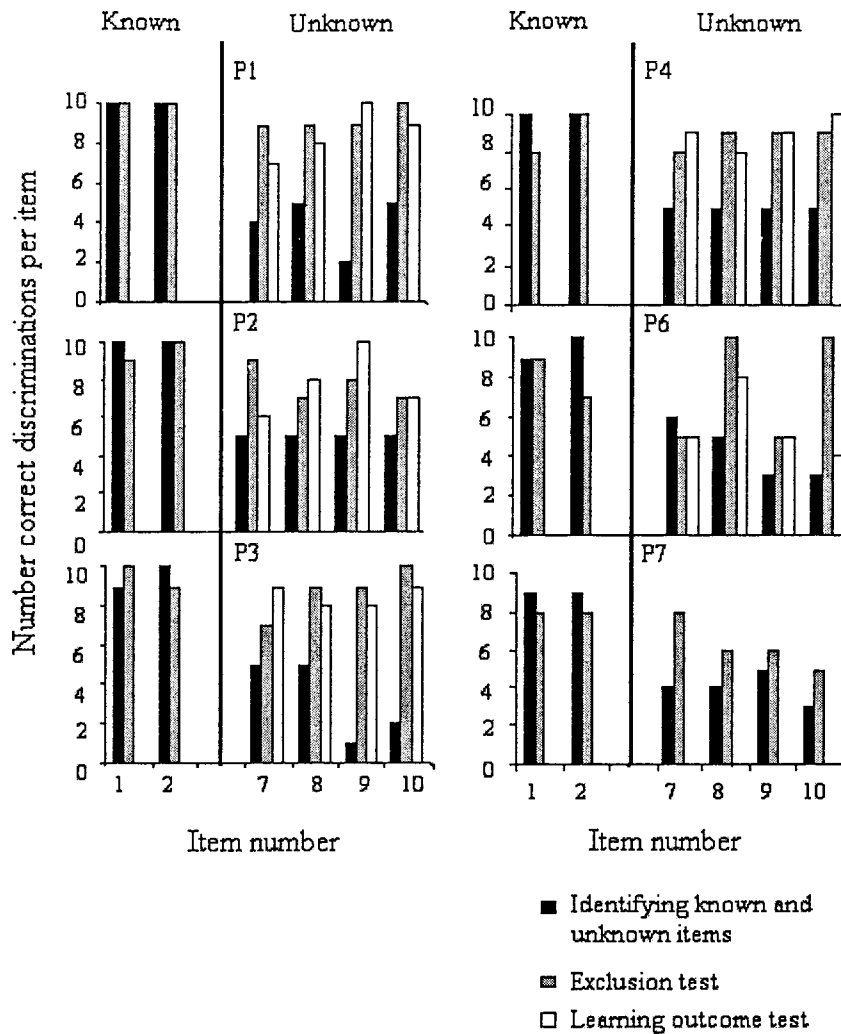
Figure 5.   In each chart, the vertical axis specifies the number of correct auditory-visual conditional discriminations achieved in each nonreinforced condition. The horizontal axis specifies the item number. The left section illustrates scores for known Items 1 and 2 during baseline tests (black bars) and during exclusion tests (gray bars). The right section illustrates scores for unknown Items 7 through 10 during baseline tests (black bars), emergent exclusion tests (gray bars), and learning outcome tests (white bars).

9 of 10 to 8 of 10 with Items 1 and 2. Correct scores for the total number of non-reinforced exclusion probe trials (Items 7 to 10) were significantly greater than chance for 5 children, using a binomial test for each set of scores: P1, 34 of 40, $p < .005$; P2, 31 of 40, $p < .005$; P3, 37 of 40, $p < .005$; P4, 35 of 40, $p < .005$; P6, 30 of 40, $p < .005$. P7's score (25 of 40) remained below chance. Figure 3 shows that exclusion-based responding by each child was considerably

more stable in Experiment 2 than in Experiment 1. However, despite his improved performance, exclusion responding was still not significantly different from chance for P7. Therefore the learning outcome test was omitted for this participant.

Learning Outcome Test Scores

Correct scores for 4 children remained above chance in the learning outcome trials: P1, 34 of 40; P2, 31 of 40; P3, 35 of 40;

P4, 36 of 40. Scores in learning outcome tests were below chance for P6, decreasing from 30 of 40 during the exclusion trials to 22 of 40 during the learning outcome trials.

Figure 3 shows that 4 children (P1, P2, P3, and P4) who achieved more stable exclusion performances across the sessions also demonstrated reliable learning outcome performances in Experiment 2. Although P6 demonstrated improved exclusion overall in Experiment 2, his performance across the sessions did not reflect the same stability as the 4 children who succeeded in learning outcome trials.

DISCUSSION

In Experiment 1, only 1 of 7 children demonstrated consistent auditory-visual exclusion performances and stable learning outcomes. In Experiment 2, performances on nonreinforced exclusion trials with new items improved for the 6 children with unstable performances in Experiment 1. Correct exclusion responses were demonstrated at a significant level for 5 of the 6 children, and 4 of these children subsequently demonstrated stable learning outcomes. Only P7 failed to demonstrate any substantial improvement either in his emergent exclusion or in his learning outcome scores in Experiment 2, compared with his performance in Experiment 1. P7's sessions each contained fewer trials than the other children received because he was able to stay on task for only short periods. Therefore, his unimproved performance could reflect reduced learning opportunities resulting from fewer reinforced exclusion trials per session and compounded by his limited attention span.

There is some question of whether the improved exclusion scores for the remaining 5 children were due to repeated exposures to exclusion trials per se rather than to a specific effect of exposure to reinforced exclusion trials. Improvements in emergent relation performances without differential rein-

forcement have been noted in previous studies, but rarely in children with severe language disabilities (e.g., Devaney, Hayes, & Nelson, 1986; Lazar, Davis-Lang, & Sanchez, 1984; Sidman, Kirk, & Willson-Morris, 1985). More directly, Wilkinson and Green (1998) reported no subsequent enhancing effect of exclusion with new stimuli after repeated experiences of successive or concurrent exclusion procedures. Therefore, although repeated exposure may be applicable to some individuals in this study, it seems unlikely that it would explain all the children's improvements in performance.

As noted previously, Figure 3 shows improvement over test blocks of nonreinforced exclusion trials for 2 children (P1 and P5) in Experiment 1. The Derbyshire Language Scale assessments for P1 and P5 placed them at the single-word receptive level, so they had a range of words in their receptive vocabulary repertoires. Therefore it is possible that exclusion-based responding already had been established, at least in part, through previous experience of auditory-visual exclusion with linguistic relations through their naturalistic learning experiences. The repeated exposure to exclusion trials in Experiment 1 then could have provided the context necessary to stabilize exclusion in their response repertoires. This process also could have been instrumental in the more consistent exclusion performance by P1 with the new items in Experiment 2. The remaining children (P2, P3, P4, and P6) did not improve over nonreinforced exclusion trials in Experiment 1, so it seems unlikely that repeated exposure to exclusion trials per se could account for their improved exclusion performances in Experiment 2 with an entirely new range of items.

GENERAL DISCUSSION

In Experiment 1 the exclusion and learning outcome performances of 7 children

with autism and severe language disabilities was evaluated. Only P5 demonstrated consistent exclusion and positive learning outcomes at this stage. Three children (P1, P3, and P4) achieved significant overall accuracy in the exclusion test but failed to demonstrate positive learning outcomes. Consistent exclusion relations were absent for the remaining 3 children (P2, P6, and P7).

All children except P5 participated in Experiment 2, which evaluated emergent exclusion relations set in blocks with reinforced exclusion trials and subsequent performances in learning outcome tests. Exclusion errors were reduced substantially for 5 children (P1, P2, P3, P4, and P6), although it is possible that the improved performances of P1 and P4 could have been due to aspects of the experiment that were not related directly to the protocol. Exclusion scores for P7 also improved, but overall his level of accuracy remained at around chance level.

Consistent with previous observations from Romski et al. (1996), the data suggest that the effect of experience with reinforced exclusion trials varied according to the child's entry level of linguistic achievement. The least linguistically advanced children were P6 and P7, both of whom were placed at the preverbal receptive level in their Derbyshire Language Scheme assessments. Improvements in exclusion scores in Experiment 2 were substantial but unstable for P6 and limited for P7, and neither child demonstrated positive learning outcomes. By contrast, the remaining children, who were placed at the single-word receptive level, eventually all demonstrated consistent exclusion relations and positive learning outcomes.

It is notable that although Wilkinson and Green (1998) found their successive exposure procedure to be more effective than concurrent exposure, the current study found enhanced effects using a concurrent exposure procedure with multiple exemplars.

This procedure produced receptive learning of four new nouns for some of the participants. Furthermore, the participants in this study demonstrated transfer of exclusion responding to new stimuli, which was not evident in Wilkinson and Green. However, the participants in the current study received a richer schedule of reinforcement compared with Wilkinson and Green's participants. It is thus possible that if Wilkinson and Green had used an equally rich schedule, the outcomes of their study may have been comparable to those in the current study. A more systematic comparison of reinforcement-based protocols with concurrent and successive exclusion procedures would help to clarify this outcome.

Conceptually, the enhancing features in both studies could be attributed to the same source. Wilkinson and Green (1998) suggested that their procedure was consistent with recommendations by Soraci, Deckner, Baumeister, and Carlin (1990) for enhancing the salience of stimulus relations by highlighting the contrast between newly known and unknown pictures. There was no change to the physical properties of the stimuli in either study, which could have emphasized the contrast between them. However, the changes in stimulus control that defined the stimulus relations were highlighted through the teaching procedures in both studies. Wilkinson and Green highlighted negative stimulus control by providing participants with experiences of the positive stimulus (i.e., the correct stimulus for selection in conditional discriminations) being changed to a negative stimulus (i.e., the incorrect stimulus for selection in conditional discriminations) over successive sessions. In Experiment 2 of the current study, the manipulation was similar because the reinforcement contingency encouraged participants to reject the stimulus that had previously been identified as positive (i.e., the

known stimulus) and instead to select the unknown stimulus in exclusion trials.

The current study brought together many of the elements that the logic of RFT might predict would facilitate the development of generalized exclusion responding. It included the provision of reinforced experiences of exclusion responding using multiple exemplars. Furthermore, there was immediate opportunity to transfer the response to new items presented in the same context. However, the specificity of the outcomes to RFT is somewhat limited because the nonreinforced exclusion trials were mixed in the same trial blocks as the reinforced or corrected exclusion trials. Therefore the nonreinforced exclusion performances were produced contemporaneously with reinforced trials rather than in an historical context. An additional set of nonreinforced trials with new items and without reinforced exemplars would have helped to clarify whether exclusion responding was maintained in accordance with the reasoning of RFT, that a relational frame may be established as a generalized operant response class on the basis of a history of reinforcement across exemplars. Moreover, it should be possible to evaluate whether contemporaneous exposure to reinforced trials may be a useful, or even necessary, intermediate step in establishing exclusion-based responding as a prerequisite before exposing individuals to complete sets of nonreinforced trials as a test for generalized exclusion responding.

Most of this study's limitations have been discussed previously in relation to individual performances. However, the greatest compromise seems to have been in using concrete nouns, because this necessitated extensive preassessment to identify which nouns were already established or otherwise in each child's receptive vocabulary repertoire. In some respects, the outcomes might have been clearer if the study had used completely novel abstract stimuli to limit the effects of

response history with the participants. Initially, concrete nouns were used because gaining access to participants depended on the use of educationally relevant materials. Moreover, the use of concrete nouns that already may have been familiar to the children had an additional benefit. It afforded the opportunity to explore the translation from laboratory-derived principles into applied procedures that can accommodate previously unproductive response histories with the stimuli. In Experiment 1, 5 children (P2, P3, P4, P6, and P7) did not demonstrate either gradually improving or stable exclusion responding through exposure to nonreinforced examples of exclusion. In Experiment 2, there was strong evidence that the multiple-exemplar reinforcement-based protocol was effective in improving exclusion responding with 4 children (P2, P3, P4, and P6). Furthermore, for 3 of these children (P2, P3, and P4), improved exclusion performances were matched subsequently by improved learning outcomes with the unknown nouns. Therefore this procedure seems to have overridden previously unproductive histories of responding with the concrete stimuli by at least 3 children in the current study.

In view of the similarities between exclusion-based responding in behavior-analytic research and disambiguation of new vocabulary in psycholinguistic fast-mapping research, the outcomes in this study are particularly relevant to a cross-disciplinary perspective on language intervention. Participants in psycholinguistic studies frequently have demonstrated limitations in their disambiguation performances (e.g., Mervis & Bertrand, 1995; Rice et al., 1990; Romski et al., 1996). Moreover, Romski et al. observed that participants with language disabilities who demonstrated disambiguation of new vocabulary were those who had the largest vocabulary base on entry into their study. Therefore, there seems to be a relation

between the ability to disambiguate and the acquisition rate for new vocabulary in natural language contexts. Thus, it is reasonable to suggest that individuals who develop a facility for auditory-visual exclusion responding in sets of precisely configured trials with concrete vocabulary should also benefit from this skill in more natural language contexts.

REFERENCES

Barnes, D. (1994). Stimulus equivalence and relational frame theory. *The Psychological Record, 44,* 91–124.

Barnes, D. (1996). Naming as a technical term: Sacrificing behavior analysis at the altar of popularity. *Journal of the Experimental Analysis of Behavior, 65,* 264–267.

Barnes, D., & Holmes, Y. (1991). Radical behaviorism, stimulus equivalence, and human cognition. *The Psychological Record, 41,* 19–31.

Barnes, D., & Roche, B. (1996). Relational frame theory and stimulus equivalence are fundamentally different: A reply to Saunders. *The Psychological Record, 46,* 236–256.

Carey, S. (1978). The child as word learner. In M. Halle, J. Bresnan, & G. Miller (Eds.), *Linguistic theory and psycholinguistic reality* (pp. 264–293). Cambridge, MA: MIT Press.

Carr, D., & Felce, D. (2000). Application of stimulus equivalence to language intervention for individuals with severe linguistic disabilities. *Journal of Intellectual and Developmental Disability, 25,* 181–205.

de Rose, J. C., de Souza, D. G., & Hanna, E. S. (1996). Teaching reading and spelling: Exclusion and stimulus equivalence. *Journal of Applied Behavior Analysis, 29,* 451–469.

de Rose, J. C., de Souza, D. G., Rossito, A. L., & de Rose, T. M. S. (1992). Stimulus equivalence and generalization in reading after matching-to-sample by exclusion. In S. C. Hayes & L. J. Hayes (Eds.), *Understanding verbal relations* (pp. 69–82). Reno, NV: Context Press.

Devaney, J. M., Hayes, S. C., & Nelson, R. O. (1986). Equivalence class formation in language-able and language-disabled children. *Journal of the Experimental Analysis of Behavior, 46,* 243–257.

Dixon, L. S. (1977). The nature of control by spoken words over visual stimulus selection. *Journal of the Experimental Analysis of Behavior, 27,* 433–442.

Dollaghan, C. A. (1987). Fast mapping in normal and language impaired children. *Journal of Speech and Hearing Disorders, 52,* 218–222.

Golinkoff, R. M., Hirsh-Pasek, K., Bailey, L. M., & Wenger, N. R. (1992). Young children and adults use lexical principles to learn new nouns. *Developmental Psychology, 28,* 99–108.

Hayes, S. C. (1991). A relational control theory of stimulus equivalence. In L. J. Hayes & P. N. Chase (Eds.), *Dialogues on verbal behavior* (pp. 19–40). Reno, NV: Context Press.

Hayes, S. C. (1994). Relational frame theory: A functional approach to verbal events. In S. C. Hayes, L. J. Hayes, M. Sato, & K. Ono (Eds.), *Behavior analysis of language and cognition* (pp. 9–30). Reno, NV: Context Press.

Hayes, S. C., & Hayes, L. J. (1992). Verbal relations, cognition, and the evolution of behavior analysis. *American Psychologist, 47,* 1383–1395.

Knowles, K., & Masidlover, N. (1982). *Derbyshire language scheme.* Derby, UK: Derbyshire County Council.

Lazar, R. M., Davis-Lang, D., & Sanchez, L. (1984). The formation of visual stimulus equivalences in children. *Journal of the Experimental Analysis of Behavior, 41,* 251–266.

Lipkens, R. G., Hayes, S. C., & Hayes, L. J. (1993). Longitudinal study of the development of derived relations in an infant. *Journal of Experimental Child Psychology, 56,* 201–239.

McIlvane, W. J., Kledaras, J. B., Lowry, M. J., & Stoddard, L. T. (1992). Studies of exclusion in individuals with severe mental retardation. *Research in Developmental Disabilities, 13,* 509–532.

McIlvane, W. J., Munson, L. C., & Stoddard, L. T. (1988). Some observations on control by spoken words in children's conditional discrimination and matching by exclusion. *Journal of Experimental Child Psychology, 45B,* 472–495.

McIlvane, W. J., & Stoddard, L. T. (1981). Acquisition of matching-to-sample performances in severe mental retardation: Learning by exclusion. *Journal of Mental Deficiency Research, 25,* 33–48.

McIlvane, W. J., & Stoddard, L. T. (1985). Complex stimulus relations and exclusion in severe mental retardation. *Analysis and Intervention in Developmental Disabilities, 5,* 307–321.

McIlvane, W. J., Withstandley, J. K., & Stoddard, L. T. (1984). Positive and negative stimulus relations in severely retarded individuals' conditional discrimination. *Analysis and Intervention in Developmental Disabilities, 4,* 235–251.

Merriman, W. E., & Bowman, L. (1989). The mutual exclusivity bias in children's word learning. *The Psychological Record, 48,* 407–422.

Merriman, W. E., Marazita, J., & Jarvis, L. H. (1993). Four-year-olds' disambiguation of action and object word reference. *Journal of Experimental Child Psychology, 56,* 412–430.

Mervis, C. B., & Bertrand, J. (1995). Acquisition of the novel name-nameless category (N3C) principle in children who have Down syndrome. *American Journal on Mental Retardation, 100,* 23–243.

Mervis, C. B., & Bertrand, J. (1997). Developmental

relations between cognition and language: evidence from Williams syndrome. In L. B. Adamson & M. A. Romski (Eds.), *Communication and language acquisition: Discoveries from atypical development* (pp. 75–106). Baltimore: Paul H. Brookes.

Rice, M. L., Buhr, J. C., & Nemeth, M. (1990). Fast mapping word-learning abilities of language-delayed preschoolers. *Journal of Speech and Hearing Disorders, 55,* 33–42.

Romski, M. A., Sevcik, R. A., Robinson, B. F., Mervis, C. B., & Bertrand, J. (1996). Mapping the meanings of novel visual symbols by youth with moderate or severe mental retardation. *American Journal on Mental Retardation, 100,* 391–402.

Sidman, M., Kirk, B., & Willson-Morris, M. (1985). Six-member stimulus classes generated by conditional-discrimination procedures. *Journal of the Experimental Analysis of Behavior, 43,* 21–42.

Soraci, S. A., Deckner, C. W., Baumeister, A. A., & Carlin, M. T. (1990). Attentional functioning and relational learning. *American Journal on Mental Retardation, 95,* 304–315.

Stokes, T. F., & Baer, D. M. (1978). An implicit technology of generalization. *Journal of Applied Behavior Analysis, 10,* 349–367.

Wilkinson, K. M., & Albert, A. (2001). Adaptations of fast mapping for vocabulary intervention with augmented language users. *Augmentative and Alternative Communication, 17,* 120–132.

Wilkinson, K. M., Dube, W. V., & McIlvane, W. J. (1996). A cross disciplinary perspective on studies of rapid word mapping in psycholinguistics and behavior analysis. *Developmental Review, 16,* 125–148.

Wilkinson, K. M., Dube, W. V., & McIlvane, W. J. (1998). Fast mapping and exclusion (emergent matching) in developmental language, behavior analysis, and animal cognition research. *The Psychological Record, 48,* 407–422.

Wilkinson, K. M., & Green, G. (1998). Implications of fast mapping for vocabulary expansion in individuals with mental retardation. *Augmentative and Alternative Communication, 14,* 162–170.

Wilkinson, K. M., & McIlvane, W. J. (1994a). Stimulus control analysis of exclusion-based mapping by adolescents with mental retardation: Implications for research and theories of vocabulary acquisition. *Proceedings of the 27th annual Gatlinburg Conference on Research and Theory in Mental Retardation and Developmental Disabilities,* 110.

Wilkinson, K. M., & McIlvane, W. J. (1994b). Stimulus organization and learning by exclusion: A preliminary experimental analysis. *Experimental Analysis of Human Behavior Bulletin, 12,* 21–25.

Wilkinson, K. M., & McIlvane, W. J. (1997). Contributions of stimulus control perspectives to psycholinguistic theories of vocabulary development and delay. In L. B. Adamson & M. A. Romski (Eds.), *Research on communication and language disorders: Contributions to theories of language development* (pp. 25–48). Baltimore: Paul H. Brookes.

Wilkinson, K. M., & Tager-Flusberg, H. (1998). Application of lexical principles framework for studying categorization and word learning in different populations. In S. A. Soraci & W. J. McIlvane (Eds.), *Perspectives on fundamental processes in intellectual functioning: A survey of research processes* (pp. 243–264). Stamford, CT: Ablex.

STUDY QUESTIONS

1. What is meant by the term *exclusion-based responding*, and how would this type of performance be examined (and shown) in the context of an auditory-visual conditional discrimination task?

2. Explain the purpose of each of the three phases in Experiment 1.

3. Briefly summarize the results of Experiment 1.

4. In what way did the performance of Participant 5 suggest that he had acquired an exclusion-responding repertoire prior to the study?

5. Describe the three types of trials used in the Phase 1 exclusion test in Experiment 2. What was the critical difference between this arrangement and that of Experiment 1?

6. Briefly summarize the results of Experiment 2.

7. What type of confounding may have partially accounted for the results of Experiment 2? How might the experimenter have controlled for this source of confounding?

8. What feature of the exclusion test in Experiment 2 weakens the conclusion that exclusion-based responding had emerged as a generalized response class?

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